proceedings

Abstract

Addressing the Role of Information in Synthetic Biology †

Walter Riofrio

Universidad Peruana Cayetano Heredia, 15102 Lima, Peru; walter.riofrio.r@upch.pe

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1. Introduction

It is known that living things are a type of dissipative systems. A very special class, because they manage to stay far from thermodynamic equilibrium for reasons that are internal to these systems. Living systems are good enough at capturing energy from their environment and dissipating that energy as heat. But in the middle, self-organizes, they survive and replicate themselves.

It is in this sense that my proposal is based on the assertion that all these phenomena are possible only if we think that biological information is a key property of life.

The proposal presented, asks researchers to rethink about a new conceptual framework, thus our proposal confronts the question: What are the possible causes that led the origin of life? Most of us know the importance of understanding molecular components and its interactions. However, it is also vital to find out how these chemical compounds were able to produce a dynamic self-organization minimally complex.

On the other hand, it seems that information has become a key concept in many areas of biology such as evolution, ecology, molecular biology, among others. Likewise, it is suggested that many of the most fundamental biochemical processes, within living systems, involve the transfer and processing of information.

Consequently, the concept of temporality is crucial in order to approach and adequate understanding related to the emergence of biological systems. As it is already known, these systems owe their appearance to certain very specific conditions, and I state the importance of approaching biological phenomena with concepts such as processes, timing, irreversibility, information, meaning and other associated notions [1–3].

But the main problem is we do not have yet a universal definition of biological information, clearly addressed and differentiated from, the term used in physics or computer science, for instance.

Our study itself will be focused in the relationship between biological information and biological organization [4].

2. Methods

My first task will be find ways to measure and quantify how much information is created in the dynamics of some protocellular models found in literature [5].

Moving on to the subject of synthetic protocells, it is important to be aware that not all protocell models would be capable of creating, transmitting and receiving information. It seems reasonable to think that the essence of synthetic protocells doesn't necessarily offer an extensive diversity of forms of encoding information [6].

Our final task will be to analyze and measure, with these results, changes of biological information within the evolution of bacterial quorum sensing (QS) and find out what could be accomplished by design and implementation of artificial QS devices taking into account this property [7,8].

3. Results and Discussion

My general idea is that biological information is one of the principles that make possible the emergence of prebiotic world: the dawn of life on Earth may have been caused by early emergence of biological information. This prior emergence of biological information doesn't necessarily refer to self-replication of information-coding polymers.

My proposal is to address this key property from the perspective of its origins.

I therefore offer a theory suggesting that biological information could be a causal factor responsible for self-organization phenomena and other fundamental properties of life. I contend that this model of minimal complexity could allow discovery of underlying patterns and principles of life [9–11].

Furthermore, my approach connects the ontology processes with the analysis of biological phenomena, from the perspective of complex networks theory [12]. Living systems are essentially a molecular dynamic network phenomenon.

This particular dynamic of molecular self-organizing networks, should contain information that has been created, transmitted and processed.

On the other hand, we find that living systems are able to carry and process a variety of information using the same signaling cascade, for example, in the presence of various agonists [13].

Given the factual evidence above, I am able to state with confidence that biological information holds a very unique feature, which is being inherently context-dependent, and something important to point out here is, that these different forms of transferring information, apparently share something in common: they are all related to the "fluctuations" found in the ways they are transmitted.

If I am on the right track, a form to detect and measure the transmission of biological information as fluctuation (any form of fluctuation) could be done through transfer entropy [14].

This gives me a great deal of confidence in my ability to accomplish the same goal with the Quorum-Sensing Systems.

Since there are at least three identified main Quorum-Sensing Networks; Gram Positive, Gram Negative and one I refer as Universal. I will continue working on my research to decode and understand the transmission of language present in molecular mechanisms [15].

With this end in mind, the first step is to build robust QS circuit diagrams, and to achieve this I will use the computer-aided design software tool for Synthetic Biology and use the quorum-sensing signalling peptides database.

References

1. Dupré, J. *Processes of Life: Essays in the Philosophy of Biology*; Oxford University Press: Oxford, UK, 2012.
2. Floridi, L. *The Philosophy of Information*; Oxford University Press: Oxford, UK, 2011.
3. Prigogine, I. *From Being to Becoming*; W. H. Freeman and Company: San Francisco, CA, USA, 1980.
4. Walker, S.I.; Kim, H.; Davies, P.C. The informational architecture of the cell. *Philos. Trans. A Math. Phys. Eng. Sci.* **2016**, *374*, doi:10.1098/rsta.2015.0057.
5. Pahle, J.; Green, A.K.; Dixon, C.J.; Kummer, U. Information transfer in signaling pathways: A study using coupled simulated and experimental data. *BMC Bioinform.* **2008**, *9*, 139, doi:10.1186/1471-2105-9-139.
6. Tanaka, S.; Fellermann, H.; Rasmussen, S. Structure and selection in an autocatalytic binary polymer model. *Europhys. Lett.* **2014**, *107*, 28004, doi:10.1209/0295-5075/107/28004.
7. Reading, N.C.; Sperandio, V. Quorum sensing: the many languages of bacteria. *FEMS Microbiol. Lett.* **2006**, *254*, 1–11.
8. Sifri, C.D. Quorum Sensing: Bacteria Talk Sense. *Clin. Infect. Dis.* **2008**, *47*, 1070–1076.
9. Riofrio, W. Informational Dynamic Systems: Autonomy, Information, Function. In *Worldviews, Science, and Us: Philosophy and Complexity*; Gershenson, C., Aerts, D., Edmonds, B., Eds.; World Scientific: Singapore, 2007; pp. 232–249.
10. Riofrio, W. Studies on Molecular Mechanisms of Prebiotic Systems. *Found. Sci.* **2012**, *17*, 277–289.

11. Riofrio, W. Ubiquity Symposium on “Evolutionary Computation and the Processes of Life”: Information, Biological and Evolutionary Computing. *Ubiquity* **2013**, doi:10.1145/2480354.2480356.
12. Cohen, R.; Havlin, S. *Complex Networks: Structure, Robustness and Function*; Cambridge University Press: Cambridge, UK, 2010.
13. Ingham, P.W.; Nakano, Y.; Seger, C. Mechanisms and functions of Hedgehog signalling across the metazoa. *Nat. Rev. Genet.* **2011**, *12*, 393–406.
14. Wollstadt, P.; Martínez-Zarzuela, M.; Vicente, R.; Díaz-Pernas, F.J.; Wibral, M. Efficient Transfer Entropy Analysis of Non-Stationary Neural Time Series. *PLoS ONE* **2014**, *9*, e102833, doi:10.1371/journal.pone.0102833.
15. Waters, C.; Bassler, B.L. Quorum sensing: Cell to Cell Communication in Bacteria. *Annu. Rev. Cell. Dev. Biol.* **2005**, *21*, 319–346.